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Three new species of Asparagales from the Kimberley region of Western Australia

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Abstract

Barrett, M.D. Three new species of Asparagales from the Kimberley region of Western Australia. *Telopea* 21: 25–37 (2018). *Hypoxis cavernicola* M.D.Barrett (Hypoxidaceae) and *Lomandra acicularis* M.D.Barrett (Asparagaceae) are described as new species endemic to the north-west Kimberley region of Western Australia. The status of *Borya* species in north-western Australia is reviewed. *Borya stenophylla* M.D.Barrett (Boryaceae) is described as a new species restricted to the Synnot Range in the West Kimberley. *Borya jabirabela* Churchill is restricted to western Arnhem Land in the Northern Territory, while the circumscription of the Kimberley endemic *Borya subulata* C.A.Gardner is broadened to include Kimberley specimens previously assigned to *B. jabirabela*. All new species are illustrated and amendments to existing keys presented.

Introduction

The Kimberley region is relatively depauperate in all families that have traditionally been treated under a broad concept of 'lilies'. However, many of these taxa are cryptic geophytes and/or have very restricted distributions in association with rugged sandstone. The Kimberley region of Western Australia is a difficult region to effectively survey, since the high rainfall north-western portion, where the highest number of plant taxa occur, is also extremely rugged and inaccessible. The combination of lifecycle and terrain necessitates wet season survey using a helicopter to obtain sufficient material to revise groups composed of restricted taxa with ephemeral fertile parts. This paper is a review of three such genera in the Kimberley, *Borya* Labill., *Hypoxis* L. and *Lomandra* Labill., with the addition of three new short-range endemic species. *Hypoxis cavernicola* is a distinctive dwarf geophyte restricted to rock overhangs near the upper Prince Regent River and differs in many respects from *H. nervosa*, the only other *Hypoxis* species in north-western Australia. *Lomandra acicularis* (Asparagaceae) is a distinctive resprouting perennial of rocky slopes from the same area as *H. cavernicola* and likewise is distinct in most characteristics from the only other Kimberley *Lomandra*, *L. tropica*. The genus *Borya* (Boryaceae) also contains very few taxa in north-western Australia, but tropical species have a more complex taxonomic history than *Hypoxis* and *Lomandra* and required a more thorough investigation of *Borya* in the Kimberley and the 'Top End' of the Northern Territory.

Borya species (Boryaceae) are perennials of shallow soil environments, and most species are 'resurrecting', a drought survival strategy whereby plants can desiccate to ambient humidity during the dry season, then rehydrate the same leaves the following season. Recent accounts of *Borya* by Rye (1992), Churchill (1987), and Forster and Thompson (1997) have listed two species from the Kimberley Region of Western Australia, *B. subulata* C.A.Gardner (as a rare Kimberley endemic), and *B. jabirabela* Churchill, occurring disjunctly in the north-west Kimberley and western Arnhem Land in the Northern Territory. Between 1995 and 2014, during surveys of sandstone pavement habitats, many additional populations of *Borya* have been located in the north-western Kimberley. In attempting to assign collections to species, the key characters used by Churchill (1987) and Rye (1992) were found to produce conflicting results, and to exhibit plasticity within populations and even on the same plant. This prompted a review of *Borya* in north-west Australia, in particular focusing on testa cell size and ornamentation, characters unavailable from Kimberley specimens for past treatments.

Methods

Most descriptions are based on dried herbarium specimens though in some cases fresh field or cultivated material, or material preserved in 70% ethanol was also utilised. To produce Scanning Electron Microscope (SEM) images, dry material was mounted on stubs using double-sided or carbon tape with conductive carbon paint, coated with gold using an EMITECH K550X Sputter Coater and imaged at high vacuum and high voltage (15 KVa) using a Jeol JCM 6000 NeoScope bench-top SEM housed at Kings Park and Botanic Garden.

Results of morphological assessment of Kimberley *Borya*

Borya subulata and *B. jabirabela* were described as differing in leaf characters, the leaves being inarticulate and flexible in *B. subulata*, articulate at the base and stiff in *B. jabirabela* (Churchill 1987, Rye 1992). Both authors also described a difference in stature, to 10 cm in *B. subulata*, and to 20 cm in *B. jabirabela*. A greater number of flowers in *B. jabirabela* was also noted by Rye (1992). Examination of previously utilised and new characters on hundreds of *Borya* plants of Kimberley *Borya* in the field showed that:

(1) Plant stature varied between and within populations and appears to be environmentally driven. Plants growing on deeper sandy or gravelly soil rarely reached above 15 cm, and did not form aerial stilt-roots. In contrast, plants growing in skeletal soils (and especially when the stolons emerged onto bare rock) frequently reached 40–50 cm, held aloft by thick, charcoal-textured (but not burnt) stilt-roots. Plant height is apparently influenced by fire, as aerial parts of some plants have been observed to be killed by heat from fire. Plants growing among low grass are apparently then pruned by fire, remaining low-creeping, while those on rocks can presumably escape, have many long erect stems, and possibly reach considerable ages. In several populations, both forms can occur nearby, with small plants on extensive pavements, and very large plants on more fire-protected bare sheeting rock.

(2) Leaf articulation varied between individuals within a population and sometimes within an individual. Lower leaves, and nearly all leaves on plants less than 10 cm tall (*i.e.* those growing on extensive sheeting sand flats) were inarticulate, while upper leaves in larger plants, and nearly all leaves on plants over 25 cm tall (*i.e.* those growing over extensive sheeting rock) were articulate.

(2) No difference in leaf flexibility was found between populations (with the exception of *B. stenophylla*), despite plants growing on a variety of substrates, including plants that stood in shallow water for several months of the wet season. Only one population, described as *B. stenophylla* below, had very narrow, flexible leaves that easily bent under pressure on contact. In all other Kimberley *Borya* species leaves were more rigid and had sharp terminal mucros that pierced the skin before leaves flexed or broke.

(3) The number of flowers in a head was variable within a population, spanning the ranges reported by Rye (1992).

(4) Testa cell size was found to be relatively uniform in all Kimberley specimens, but was considerably larger in Kimberley collections than in those of *B. jabirabela* seeds from the Northern Territory.

(5) Testa ornamentation in most specimens from the Kimberley was found to vary significantly with seed age. Initially seeds are ± smooth to colliculate, and become rugose as the cells dry out and collapse. In nearly all collections, the ornamentation of mature seeds was uniformly rugose, without or with only a superficial indication of a central tubercle (Fig. 1I, L). The only exception was again *B. stenophylla*, which displays a prominent but oblique-sided tubercle that becomes rugose or sulcate extending to *c.* half way up the tubercle (Fig. 1G, J). The testa morphology of *B. stenophylla* approaches *B. jabirabela* in form (Fig. 1H, K; also see Fig. 88D in Churchill, 1987), but in that species the tubercle has a distinctly aculeate apex, and is rugose below the tubercle.

I conclude from these observations that the leaf articulation character that was the basis for separating '*B. subulata*' and '*B. jabirabela*' in the Kimberley is influenced by plant age and substrate, and is not a reliable specific character. Since most populations contain large plants and these are the most obvious and most frequently collected, '*B. jabirabela*' has appeared to be more common and widespread in the Kimberley than '*B. subulata*'. The characters previously used to separate *B. subulata* and *B. jabirabela* break down in the Kimberley, and Kimberley collections previously applied to the two species appear to refer to a single taxon. *Borya subulata* is the earliest name of any north-west Australian *Borya* species, and so the concept of *B. subulata* is expanded to include material previously referred to *B. jabirabela* in the Kimberley. There are distinct differences in seed coat morphology in (Fig. 1), and floral bract apices between Kimberley and Kakadu *Borya* populations and these forms are interpreted as belonging to discrete species. Consequently *B. jabirabela* is retained but restricted to populations from a small area of western Arnhem Land. The differences between the tropical species of *Borya* are summarized in the key below.

Key to the tropical species of *Borya*

1. Leaves 14–18 mm long, minutely scabrous for entire length. Scapes 11–13 mm long. Flower heads 10–15-flowered. Floral bracts muticous, midrib obscure (North Kennedy district, Mt Stewart Ra. QLD) ..... ***B. inopinata*** **P.I.Forst. & E.J.Thomps.**

1: Leaves 25–60 mm long, minutely scabrous toward apex, with or without hairs along part or whole of margins. Scapes 10–24 cm long. Flowers 12–40 per head. Longest floral bracts weakly to sharply pungent (Qld, NT, WA) **2**

2. Scapes 10–24 cm long. [Testa of mature seeds rugose, tuberculate, see figure 88D in Churchill 1987] (QLD) ..... ***B. septentrionalis*** **F.Muell.**

2: Scapes < 10 cm long (WA, NT)..... **3**

3. Black pungent apices of longest floral bracts apiculate to shortly acuminate-pungent, much smaller (<2/3 as long) than pungent apices of involucral bracts. Testa of mature seeds aculeate-tuberculate (Fig. 1H, K). Testa cells mostly 25–40 μm in longest dimension, 3–4 per 0.1 mm in orientation of longest cell dimension (Kakadu NP, NT). ..... ***B. jabirabela*** **Churchill**

3: Black pungent apices of longest floral bracts long-acuminate-pungent, almost as long as black pungent tips of involucral bracts. Testa of mature seeds almost smooth to broadly tuberculate, never aculeate-tuberculate. Testa cells (measure at centre of seed) mostly 40–60 μm in longest dimension, *c.* 2 per 0.1 mm in orientation of longest cell dimension (Kimberley Region, WA) **4**

4. Leaf blades (when dry, measured in mid section of leaf) 0.3–0.8 mm wide. Testa of mature seeds obtusely tuberculate, tubercle apices smooth, sulcate or rugose on tubercle sides. [Testa cells measured at centre of seed (35–)40–70 μm in longest dimension, 2 per 0.1 mm] (Synnot Ra., Kimberley Region, WA) . ..... ***B. stenophylla*** **M.D.Barrett**

4: Leaf blades (dry) 0.6–1.1 mm wide, the broadest leaves on a plant 0.9–1.1 mm wide. Testa of mature seeds almost smooth or with low, broad tubercles, centre of cells or tubercles rugose with anastomosing veins (Fig. 1I, L). [Testa cells measured at centre of seed mostly 30–60 μm in longest dimension, *c.* 2 per 0.1 mm in orientation of longest cell dimension.] (Widespread in NW Kimberley Region, WA) ..... ***B. subulata*** **C.A.Gardner**

Taxonomy

Boryaceae

Borya stenophylla M.D.Barrett, **sp. nov.**

Type: Synnot Range, Western Australia, [precise locality withheld for conservation reasons], 20 Mar. 1998, *M.D. Barrett MDB 444* (*holo*: PERTH 08103011; *iso*: CANB, MEL).

Borya sp. Synnot Range (*M.D.Barrett MDB 444*), Western Australian Herbarium, in *FloraBase*, http://florabase.dpaw.wa.gov.au [accessed 01 March 2014].

Small tussock perennial resurrection plant, turning orange at the onset of desiccation, vegetative parts to 15 cm and emergent inflorescences to 25 cm. *Stems* erect to decumbent and stoloniferous, forming stilt-roots on larger plants. *Leaf blade* linear, flexible, articulate near base above level of sheathing margins, 19–59 mm long, 0.3–0.8 mm wide (slightly larger and to 0.9 mm wide when hydrated), apex black-brown, pungent terminal

1.5–2.5 mm, margins smooth or with very sparse white hairs 0.1–1.0 mm long scattered on margins, orange-red when drying, straw when dry, leaf base gradually dilated to sheath; *sheaths* persistent on old stems, 10–12 mm long, 1.8–2.3 mm wide, margins brownish, membranous, entire, glabrous for most of length but with sparse to dense stiff white hairs 2–5 mm long hairs at apex of dilated portion. *Inflorescence* a head, 8–11 mm long, 7–14 mm diam., depressed globose to broadly ovate in outline (excluding bracts), of 21–39 flowers. *Scapes* 34–92 mm long, glabrous, ribbed. *Inflorescence bracts* 13–18, irregularly 2–3-seriate, 8–21 mm long, sheathing base 4–7 mm long, 1.5–2 m wide at base, flattened and weakly differentiated from the blade, blades 1.5–24 mm long, 0.4–0.6 mm wide, outermost bracts with longest blades, on innermost bracts the blade short and sometimes reduced to a pungent mucro, apex pungent on all involucral bracts, initially green, drying with orange tints, then soon straw then grey. *Rachis* narrowly conical, 4–6 mm long, persistent. *Floral bracts* 2 per flower, sometimes separated by an internode 0.1–0.5 mm long; lower (outer) bract heavily indurated and coriaceous, straw coloured except black apex, narrowly ovate, 8.0–9.2 mm long, 2–2.2 mm wide, acuminate, with a strong keel (weak in basal 1/5–1/3), bordered by shallow but sharply bordered grooves, running into a prominent black pungent spine *c.* 0.5–1 mm long; upper (inner) bract membranous, acute to subacute, pale straw-coloured, ovate, 5.3–6.5 mm long 2.0–2.9 mm wide, with 2 narrow but distinct, widely spaced keels which run almost to the apex but not into a sharp point. *Corolla*: perianth tube 5–7 long, perianth lobes 6, 3–4 mm, white; *staminal filaments* exserted, adnate to corolla tube for entire length of tube, free part of filament 2–3 mm long; *anthers c.* 0.7–0.8 mm long, *c.* 0.3 mm diam. *Style* cylindrical, *c.* 6–7 mm long, exserted for *c.* 5 mm, stigma held slightly above level of stamens. *Ovules* several per locule, but maturing at most a single seed per locule (apparently usually the lowest ovules developing – all seeds seen sit in the lower half of the capsule). *Capsule* 3-valved, valves opening to base when mature, septum remaining connate to *c.* 1/3 of height, outer surface probably initially smooth apart from midline groove, but becoming wrinkled with age (sometimes minutely transversely striate), straw-coloured, 2.6–4.5 mm long, 1.3–2.2 mm wide, lenticular to elliptical in outline, apex acute, gaping after seed release. *Seeds* subglobose to broadly ellipsoid, not or only very weakly laterally compressed, 0.8–1.2 mm long, smooth to colliculate and dark reddish-brown when young, ± uniformly weakly broad-tuberculate all over when mature, tubercles broader than high to almost as high as broad, with apex smooth and sides or tubercle sulcate or ±radially rugose, testa cells (35–)40–70 μm in longest dimension, 2 per 0.1 mm. **Fig. 1A–G, J**.

Distribution: Only known from a small area a few kilometres across in the Synnot Range on Charnley River (previously Beverley Springs) Station in the West Kimberley region of Western Australia.

Habitat: *Borya stenophylla* grows on sand flats over low outcropping sandstone in low open woodland over grassland. These sand flats are large and open, and the distribution of *Borya* on them is patchy and often seemingly random. The dominant vegetation on the surrounding plain is annual *Sorghum stipoideum* and *Terminalia canescens*, and *B. stenophylla* typically occurs in monospecific stands often in bare 'islands' within dense *Sorghum* fields, perhaps associated with skeletal soils over subsurface or scarcely outcropping rock. In contrast, *B. subulata* always occurs in association with thin soils over sandstone pavements on massive sheeting sandstone, more clearly separated from any stands of *Sorghum* or other large grasses, and is presumably exposed to less frequent fires as a result. The Synnot Plateau is somewhat isolated from the Gardner Plateau to the north and east where *B. subulata* occurs. There are broad red loam or cracking clay savannah woodlands surrounding the Synnot Plateau, and this isolation may have contributed to speciation from *B. subulata*.

Flowering/fruiting: recorded for January, flowering finished by early March.

Additional specimens: WESTERN AUSTRALIA: [locality withheld for conservation reasons]: 13 Mar. 2014, *R.L. Barrett RLB 9025* (PERTH).

Etymology: The epithet is from the Greek *stenos* (slender, narrow) and *phyllum* (leaf), in reference to the soft, slender leaves of this species relative to *B. subulata* C.A.Gardner.

The vernacular name of Synnot Range Borya is suggested.

Conservation status: *Borya stenophylla* is listed by Jones (2015) as Priority One under Department of Parks and Wildlife Conservation Codes for Western Australian Flora, under the name *Borya* sp. Synnot Range (*M.D.Barrett MDB 444*). *Borya stenophylla* is only known from the type location. The population when examined in 1998 was estimated to contain at least 1000 tussocks, many of which may have been clones, however the population may be larger than recognised. Only two tussocks were located in the same area in 2014, however only limited time was spent searching.

Notes: Originally discovered by R.L. Barrett on the 1995 *Landscope* Expedition to Bachsten Creek, flowering material was located by M.D. Barrett in 1998.

Borya stenophylla is most similar to *B. subulata*, sharing subglobose to broadly elliptic, not or scarcely compressed seed seeds, pungent floral bracts and large testa cell size, but differs in having more tuberculate

seeds and narrower leaf blades. *Borya stenophylla* grows in shallow soil over scarcely outcropping sandstone, a relatively deep soil for Kimberley *Borya*, and plants have not been observed to form large stilt roots or elongated erect stems, but tussocks form only to *c.* 15 cm tall. *Borya subulata* frequently grows to 40–50 cm high in large stilt-rooted domes where it grows over sandstone or shallow soils, but occasionally in deeper sand (e.g. at the type location at Mt Agnes) grows with a similar habit to *B. stenophylla*.

Borya jabirabela Churchill, *Fl. Austral.* 45: 468, 270 (1987). *Type*: Cultivated at Royal Botanic Gardens Melbourne from *L.A. Craven* 6280, 28 Feb. 1984, *D.M. Churchill s.n.* (*holo*: MEL 628555).

The description of Churchill (1987) is based on Northern Territory plants of *B. jabirabela* s.s., as Kimberley specimens attributed to it were largely infertile. To this description I add: Black pungent apices of longest floral bracts apiculate to shortly acuminate-pungent, much smaller (<2/3 as long) than pungent apices of involucral bracts. Testa of mature seeds aculeate-tuberculate (Fig. 1H, K); testa cells mostly 25–40 μm in longest dimension, 3–4 per 0.1 mm in orientation of longest cell dimension.

Specimens examined: NORTHERN TERRITORY: near Baroalba Creek, 21 Nov. 2010, *K. Brennan 8778* (DNA); SE of Jabiru, 6 Mar. 1980, *L.A. Craven 6280*, (AD *n.v.*, CANB *n.v.*, DNA, MEL); near Mt Gilruth, 22 Feb. 1977, *C.R. Dunlop 4430* (CANB *n.v.*, DNA, MEL); SE of Oenpelli, 13 June 1978, *P.K. Latz 7750* (CANB *n.v.*, DNA, MEL, PERTH); SSE of Jabiru, 2 June 1980, *M. Lazarides 9139* (CANB *n.v.*, DNA, MEL); Kakadu Nat. Pk., 27 Mar. 2002, *G.J. Leach & D.J. Dixon 4678* (DNA); Mann River, 13 Sept. 2000, *C.R. Michell 2584* (DNA); Kakadu Nat. Pk., 18 Mar. 1985, *J. Russell-Smith 10322* (DNA).

Conservation status: *Borya jabirabela* is currently considered Near Threatened in the Northern Territory.

Borya subulata C.A.Gardner, *West. Aust. For. Dept. Bull.* 32: 38 (1923). *Type*: near Mount Agnes, Kimberley, Western Australia, 26 June 1921, *C.A.Gardner 1427* (*holo*: PERTH 01115286; *iso*: PERTH 01115294).

Descriptions of *B. subulata* can be found in Churchill (1987) and Rye (1992, as *B. jabirabela* and *B. subulata*). To these I add the observations: Leaf blades (dry) 0.6–1.1 mm wide, the broadest leaves on a plant 0.9–1.1 mm wide. Black pungent apices of longest floral bracts long-acuminate-pungent, almost as long as black pungent tips of involucral bracts. Testa of mature seeds almost smooth or with low, broad tubercles, centre of cells or tubercles rugose with anastomosing veins (Fig. 1I, L); testa cells (measure at centre of seed) mostly 30–60 μm in longest dimension, *c.* 2 per 0.1 mm in orientation of longest cell dimension.

Distribution: Occurs across the north-west Kimberley from the Artesian Range north to west of Mitchell Plateau, and an isolated area of the Drysdale River National Park in the central-north Kimberley. Within this area it is restricted to small isolated patches of suitable sandstone pavement habitat.

Habitat: Restricted to sandstone pavements, i.e. shallow sand over massive sheeting sandstone.

Conservation status: *Borya subulata* is currently listed by Jones (2015) as Priority Four under Department of Parks and Wildlife Conservation Codes for Western Australian Flora, following the recent large number of additional collections. Although plants are killed by fire, and it might conceivably be affected by changes in fire regime, most populations seem fairly well protected by their occurrence on massive and often almost bare sheeting sandstone.

Specimens examined: WESTERN AUSTRALIA: 14 Mar. 1998, *M.D. Barrett 360*, (PERTH); E of Mt Agnes, 19 Mar. 1998, *M.D. Barrett 414* (PERTH); 19 Mar. 1998, *M.D. Barrett 422* (PERTH); 19 Mar. 1998, *M.D. Barrett 436* (PERTH); 20 Mar. 1998, *M.D. Barrett 468* (PERTH); 25 Jan. 2000 *M.D. Barrett 885* (PERTH); 29 Jan. 2000, *M.D. Barrett 963* (PERTH); 4 Jan. 2001, *M.D. Barrett & R.L. Barrett MDB 1079* (PERTH); 22 Apr. 2008, *M.D. Barrett & R. L. Barrett MDB 1937* (PERTH); 28 Mar. 2010, *M.D. Barrett & R.L. Barrett MDB 2882* (PERTH); 5 Jan. 1995, *R.L. Barrett & M.D. Barrett RLB 8745* (PERTH); 10 July 1995, *R.L. Barrett & M.D. Barrett RLB 8611* (PERTH); 12 Jan. 2001, *R.L. Barrett & M.D. Barrett RLB 1768* (DNA, PERTH); 19 Jan. 2007, *R.L. Barrett, M.D. Barrett & P. Kendrick RLB 3612* (CANB, DNA, NSW, PERTH); 22 Jan. 2007, *R.L. Barrett & M.D. Barrett RLB 3737* (PERTH); 25 Jan. 2007, *R.L. Barrett & M.D. Barrett RLB 3859* (PERTH); 25 Jan. 2007, *R.L. Barrett & M.D. Barrett RLB 3911* (PERTH); 29 Apr. 2008, *R.L. Barrett & M.D. Barrett RLB 4888* (PERTH); 29. Apr. 2008, *R.L. Barrett & M.D. Barrett RLB 4891* (PERTH); 13 Jan. 2010, *R.L. Barrett, M. Maier & P. Kendrick RLB 5992* (PERTH); 30 Mar. 2010, *R.L. Barrett & M.D. Barrett RLB 6872* (PERTH); 11 Apr. 2013, *R.L. Barrett, M.D. Barrett & B. Anderson RLB 7968* (PERTH); 11 Apr. 2013, *R.L. Barrett, M.D. Barrett & B. Anderson RLB 7994* (PERTH); 13 Mar. 2014, *R.L. Barrett RLB 9019* (PERTH); 10 June 1985, *P.A. Fryxell, L.A. Craven & J.McD. Stewart 4738* (AD *n.v.*, DNA, MEL); 21 July 2001, *T. Handasyde & A.N. Start TH 01 185* (DNA, PERTH); 20 Nov. 1993, *C.P. Johnstone 3339* (PERTH); 31 May 1998, *R.O. Makinson 1680* (PERTH); 2 June 1998, *R.O. Makinson 1689* (PERTH); 20 July 1992, *K. Menkhorst 1084* (PERTH); 23 July 1992, *K. Menkhorst 1090* (DNA, MEL, PERTH); 8 June 1988, *W.M. Molyneux s.n.* (PERTH); 9 Aug. 2001, *R.C.H. Shepherd 61* (MEL).

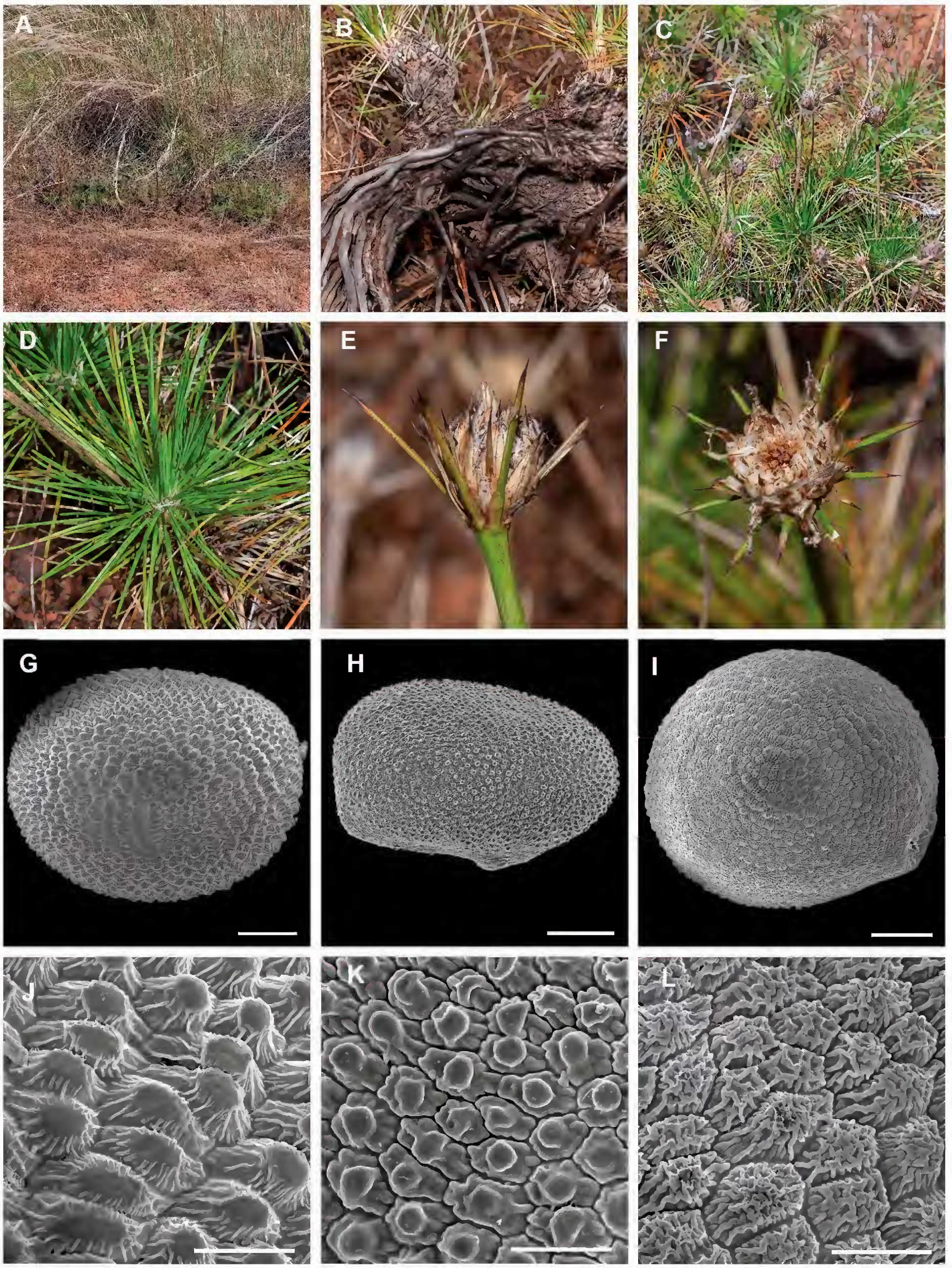

Fig. 1. *Borya stenophylla*. **A**, habitat; **B**, stilt roots on old plants; **C**, habit; **D**, fruiting plant; **E**, lateral view of fruiting inflorescence; **F**, top view of fruiting inflorescence; *Borya jabirabela*. **G**, SEM of seed; **J**, SEM of seed surface detail; *Borya subulata*. **H**, SEM of seed; **K**, SEM of seed surface detail; **I**, SEM of seed; **L**, SEM of seed surface detail. Scale bars = 200 μm (G–I); 50 μm (J–L). Images from *R.L. Barrett RLB 9025* (A–F); *M.D. Barrett MDB 444* (G, J); *K.G. Brennan 260*, DNA (H); *M.D. Barrett MDB 360* (I, L) and *L.A. Craven 6280*, BRI (K). Photographs by R.L. Barrett (A–F); M.D. Barrett (G–L).

Asparagaceae

Lomandra acicularis M.D.Barrett, **sp. nov.**

Type: Edkins Range, Western Australia, [precise locality withheld for conservation reasons], 22 Jan. 2007, *R.L. Barrett & M.D. Barrett RLB 3725* (*holo (male plant)*: PERTH 08042578; *iso*: CANB, DNA).

Paratype: Edkins Range, Western Australia, [precise locality withheld for conservation reasons], 22 Jan. 2007, *R.L. Barrett & M.D. Barrett RLB 3725B* (*para (female plant)*: PERTH 08935904, CANB, DNA).

Perennial, rhizomatous, glabrous, dioecious *herbs*, forming dense clumps, resprouting after fire. *Rhizomes* short. *Leafy stems* ±erect, short, very densely tufted. *Leaves* basal, flexible, very narrowly linear, flat or bi-convex, 19–62 cm long, 0.5–0.9 mm broad, apex sharply acute, nerves 5–7(–12), obscure to moderately prominent, midrib not especially differentiated, glabrous, margins moderately to strongly tuberculate, dull green to mid-green; *sheathing bases* paler, margins membranous and usually splitting into fibres, long-tapering at apex of sheath. *Male inflorescences* erect, rachis unbranched, 0.7–0.9 mm diam., angular, glabrous, 8–16 cm long, bearing 7–12 ±globular clusters of *c.* 10–20 flowers, subtended by one conspicuous cluster bract usually greatly exceeding the flower cluster, cluster bract lanceolate to narrowly ovate at base, drawn out into a long-subulate then acicular (pungent) apex, 2.5–13 mm long, 1.2–1.5 mm wide at base, straw-coloured, glabrous. *Intermediary bracts* present within the cluster, subtending (1–)2 flowers, *c.* as long as or slightly longer than the flowers, lanceolate, *c.* 3.0 mm long, *c.* 1.0 mm wide, membranous on margins and a strongly thickened midrib running into a long, rigid, pungent arista almost as long as or longer than the body. Each male flower subtended by two *bracteoles*; bracteoles split, often almost to base, into 2–3 parts, membranous, broadly lanceolate to broadly ovate, 1.3–1.5(–2.0 with apiculus) mm long, 1.0–1.5 mm broad, lowermost bracteole apices (or only mid-lobe) usually with a distinct rigid and often pungent apiculus up to *c.* 1 mm long, apices otherwise acute or with a short usually blunt apiculus. *Female inflorescence a solitary* capitate or sub-capitate head (sometimes 1–2 flowers a little below the main cluster) at or near ground level, 8–15 mm long, 5–12 mm wide, hidden among the leaves, bearing a single terminal cluster of *c.* (2–)4–5 flowers. Each *female flower* subtended by a conspicuous bract and three smaller bracteoles; *bract* coriaceous, narrowly lanceolate to subulate, 4–12 mm long, 2.0–2.5 mm broad at base, 1–3-nerved with strong mid-rib, apex long-triangular and pungent, straw-coloured; *bracteoles* 2.0–3.5 mm long, 2.0–3.0 mm broad at base, apex acute to shortly acuminate-pungent or sub-acicular and up to 3.5 mm long, lacking distinct veins or midrib. *Male flowers* cream to yellowish, sometimes brownish-purple on tepal apex, obovate to elliptical, 2.2–3.0 mm long, sessile. *Male tepals* connate in lower half, faintly 1-nerved (sepaline) or not (petaline), ±erect at anthesis, differentiated into an outer sepaloid whorl and an inner petaloid whorl; *outer tepals* slightly longer, slightly thicker, and more acute at apex than inner tepals, ±fleshy when fresh, ±triangular, free part 1.0–1.4 mm long, 0.6–0.7 mm broad; *inner tepals* shorter and more muticous at apex, narrowly ovate to almost triangular, 0.7–1.2 mm long, 0.5–0.7 mm broad. *Stamens* equal in length, 0.6 mm long, inserted a little above the level of tepal fusion. *Rudimentary ovary* not clearly distinct. *Female flowers* larger, yellowish with purple tepals apices, 4.2 mm long, sessile. *Tepals* free except at extreme base, 1-veined or petaline tepals not veined, differentiated into inner and outer whorl; *outer tepals* longer and broader, membranous-coriaceous, lanceolate to narrowly ovate, 3.5–3.8 mm long, 1.5–2.0 mm broad, apex acute; *inner tepals* shorter, a little more fleshy or membranous, lanceolate to narrowly elliptic (or one very narrowly oblong), apex acute, 3.0–4.0 mm long, 0.8–1.2 mm broad. *Staminodes* not observed. *Ovary* ±turbinate, 1.3–1.7 mm long, 1.0–1.1 mm diam. at anthesis. *Stigmas* sessile on ovary. *Capsule* ±globular, 7–9 mm long, 7.5–8.5 mm diam., trigonous in section, 3-valved, outer surface transversely wrinkled, glabrous, apex with a short thick abrupt conical point. *Seeds* (only 1 seen) very broadly elliptic (subglobular), 4.0 mm long, 3.5 mm diam., ochraceous, smooth. **Fig. 2.**

Distribution: Occurs in the southern Prince Regent National Park and adjacent areas, between Bachsten Creek and Mt Bomford, a maximum range of about 70 km.

Habitat: Grows on rocky sandstone slopes or occasionally on shallow sand between sandstone ridges in open woodland, with *Chrysopogon* sp., *Boronia* sp. cf. *pauciflora*, *Haemodorum interrex*, *Sauropus torridus, Sorghum stipoideum* and *Triodia* spp.

Flowering/fruiting: recorded January to February.

Additional specimens: WESTERN AUSTRALIA: [localities withheld for conservation reasons]: 2 Feb. 2000, *M.D. Barrett MDB 1036* (PERTH); 4 Jan. 2001, *M.D. Barrett & R.L. Barrett MDB 1068* (AD, BRI, PERTH); 4 Jan. 2001, *M.D. Barrett & R.L. Barrett MDB 1068B* (DNA, PERTH); 5 Jan. 2001, *M.D. Barrett & R.L. Barrett MDB 1085* (K, PERTH); 9 Jan. 2001, *M.D. Barrett MDB 1151A* (MEL, PERTH); 9 Jan. 2001, *M.D. Barrett MDB 1151B* (PERTH); 11 Jan. 2001, *M.D. Barrett & R.L. Barrett MDB 1203* (PERTH); 21 January 2007, *R.L. Barrett & M.D. Barrett* RLB 3700 (CNS, NSW, PERTH); 22 Jan. 2010, *R.L. Barrett & M.D. Barrett RLB 6333* (PERTH); 25 Jan. 2010, *M. Maier & P. Kendrick per R.L. Barrett RLB 6516* (PERTH).

Etymology: The epithet is from the Latin *acicularis* (narrow, stiff, pointed, like a needle), in reference to the distinctive cluster bracts in the male inflorescence.

The vernacular name of Kimberley Mat-rush is suggested.

Conservation status: *Lomandra acicularis* is listed by Jones (2015) as Priority Two under Department of Parks and Wildlife Conservation Codes for Western Australian Flora. The species is conserved in the Prince Regent National Park.

Notes: *Lomandra acicularis* belongs to section *Capitatae* (G.Don) A.T.Lee *sensu* Lee and Macfarlane (1986), by virtue of having entire prophylls, capitate female inflorescences and tepals connate in the basal half in male flowers. There are nine other described species recognised in section *Capitatae*. Lee and Macfarlane (1986) treated the group as an Australia-wide complex; however, Donnon (2009) did not recover the section as monophyletic, instead a core group comprising mostly species of sect. *Capitatae* was recovered with a few other accessions of species belonging to other sections nested within it, and some accessions of species belonging to sect. *Capitatae* recovered remote from the 'core' clade. While hybridisation was suggested as a possibility for the non-monophyly of sect. *Capitatae* for the unusual position of some taxa, it seems less likely for others (Donnon 2009). Sect. *Capitatae* is here used in the sense of Lee and Macfarlane (1986) pending further clarification of the phylogenetic data. Within section *Capitatae sensu* Lee and Macfarlane (1986), the very long cluster bracts are unique; all other species with capitate female heads and basally connate tepals in male flowers have cluster bracts on male inflorescences obscured by the flowers. In addition, *L. acicularis* differs from other species in the section by having a combination of an unbranched male inflorescence, tuberculate leaf margins, tapering sheath apex, male flowers 2.2–3.0 mm long and leaves 0.5–0.9 mm wide.

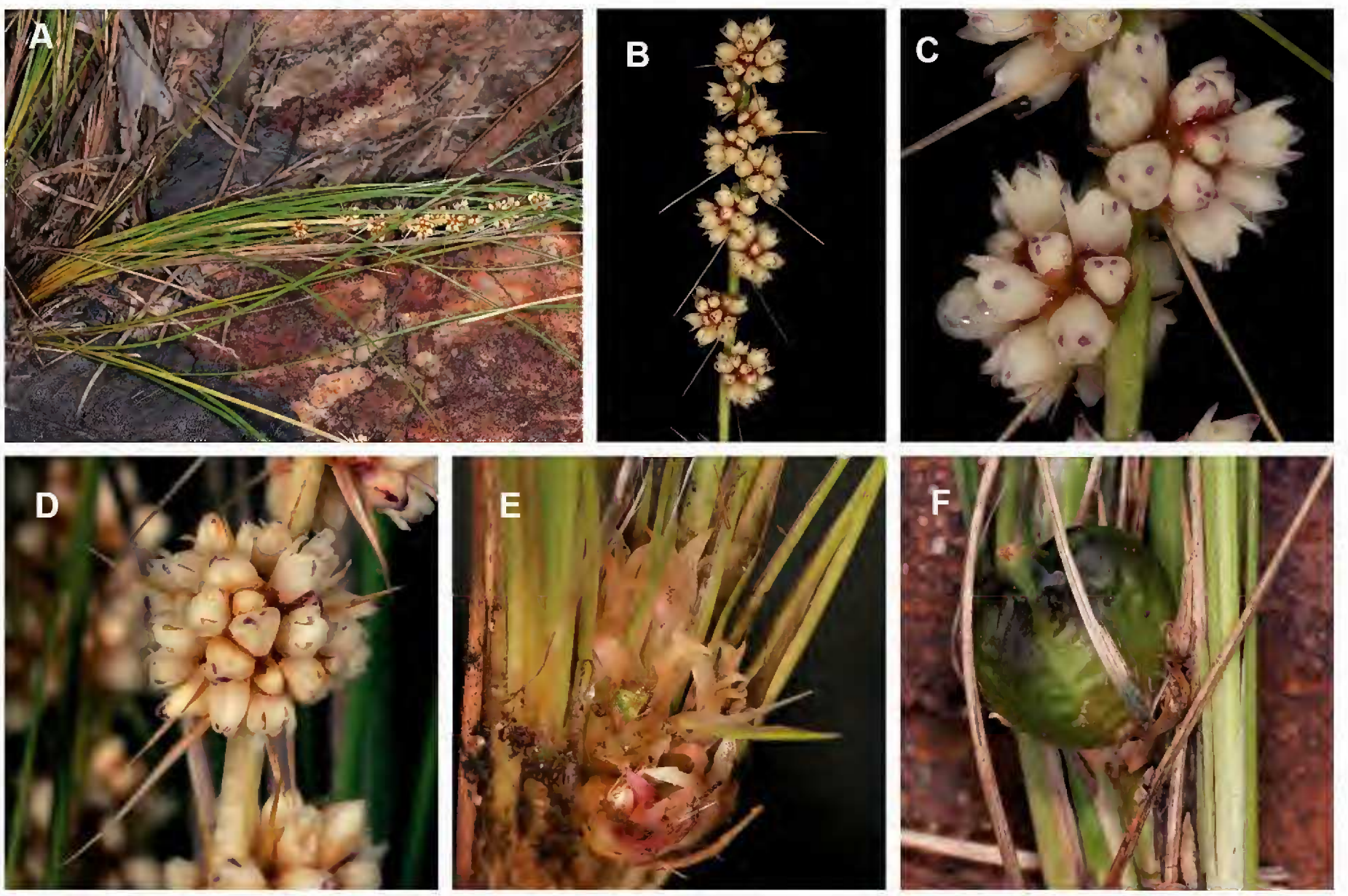

Fig. 2. *Lomandra acicularis*. **A**, flowering male plant in situ showing the densely caespitose habit and unbranched male inflorescences; **B**, male inflorescence, showing the characteristic acicular cluster bracts; **C**, **D**, variation in male flower clusters; **E**, female inflorescence; **F**, fruit. Scale bars = 10 mm (C); 1 mm (D, E). Images from *R.L. Barrett & M.D. Barrett RLB 3700A* (A, D); *R.L. Barrett & M.D. Barrett RLB 6333* (B, C) and *R.L. Barrett & M.D. Barrett RLB 3700B* (E, F). Photographs by R.L. Barrett (A, D–F); M.D. Barrett (B, C).

The key in *Flora of Australia* (Lee & Macfarlane 1986: 10) can be modified to include the new species by adding the following couplet after the first lead of couplet 3:

3A. Cluster bracts on male and female inflorescences up to 13 mm long, greatly exceeding the flower clusters. Male flowers 2.2–3.0 mm long. Male inflorescence unbranched ..... ***L. acicularis***

3A: Cluster bracts at least in male inflorescences short and obscured by the flowers.
Male flowers either *c.* 2 mm long or else 3.5–6 mm long ..... **(4)**

Only one other *Lomandra* taxon, *L. tropica* subsp. *tropica*, occurs sympatrically with *L. acicularis*. The two species can be separated by the narrow leaves 0.5-0.9 mm wide, and branched male inflorescences with long, needle-like cluster bracts in *L. acicularis* (leaves usually (1–)1.5–3.5 mm wide, male inflorescence unbranched and with inconspicuous acute cluster bracts in *L. tropica* subsp. *tropica*). Three species are known from the adjacent Top End of the Northern Territory, but only *L. tropica* has capitate female inflorescences. The very narrow leaves of *L. acicularis* are reminiscent of *L. tropica* subsp. *arnhemica* A.T.Lee (with leaves 0.3–1.3 mm wide) from the Northern Territory; however, they can immediately be distinguished by the leaf margins, which are tuberculate in *L. acicularis*, vs. smooth in *L. tropica* subsp. *arnhemica*. *Lomandra tropica* subsp. *tropica* can have tuberculate leaf margins.

Hypoxidaceae

Hypoxis cavernicola M.D.Barrett, **sp. nov.**

Type: near Prince Regent River, Western Australia, [precise locality withheld for conservation reasons], 27 January 2000, *M.D.Barrett 924B* (*holo*: PERTH 06348114; *iso*: CANB).

Hypoxis sp. Prince Regent River (*M.D.Barrett 924B*), Western Australian Herbarium, in FloraBase, http://florabase.dpaw.wa.gov.au [accessed 01 March 2014].

Perennial cormous *herb* 5–8 cm high. *Corms* solitary, perennial, condensed, 4–6 mm long, 3–4 mm diam., tunic fibrous, *roots* medial, fleshy-fibrous. *Leaves: sheaths* 5–6 mm long; *leaf blades* 5–7, lamina V-shaped in section, the midvein much enlarged, 3–5-veined but lateral veins scarcely visible when fresh, linear, 15–92 mm long, (1.0–)1.6–1.8 mm wide, sparsely pilose, the hairs to 2 mm long, white. *Inflorescences* 2–3 per plant, peduncles 32–64 mm long, each 1–3-flowered (sometimes more in cultivated plants), axes moderately densely silky-hairy, the hairs 1.6–2 mm long, pedicels 7–19 mm long, not expanding in fruit. *Bracteoles* present but variable in number and position, from 2 bracteoles well below the flower (in solitary flowers), or in branched inflorescences 1–2 bracteoles at or a little below the lowest branch and then 2 bracteoles c. midway along the shortest pedicel but not the longest, bracteoles 1–2 mm long, narrowly linear. *Perianth segments* all quite similar, free, yellow adaxially, in two whorls. *Sepals* 2.8–3.1 long. 1.34–1.75 mm wide, glabrous except for a bundle of hairs and a subulate apical appendage at the abaxial apex, pale yellow-green abaxially. *Petals* slightly shorter and narrower than sepals, 2.4–2.9 long, 0.98–1.13 mm wide, glabrous. *Stamens* 6, aligned with perianth segments, 0.8–1.5 mm long, *c.* 0.08 mm wide, filaments (excluding anthers) alternately long and short, longer (sepaline) filaments 1.0–1.4 mm long, shorter (petaline) filaments 0.8–1.1 mm long; *anthers* 0.4–0.6 mm long, *c.* 0.45 mm wide, attached near middle, connective joining the cells in the upper half. *Style* columnar, 1.15–1.3 mm long, papillose in apical 0.18–0.23 mm, the papillae *c.* 0.035 mm long. *Ovary* inferior, turbinate at anthesis, 1.2 mm long, 1.4 mm diam., 3-locular, very sparsely silky-pilose externally. *Capsule* ±globular, 5.5 mm long including erect persistent tepals, body 2.2–3.0 mm long, 2.4–3.0 mm diam., very sparsely hairy, closed perianth lobes 3.1–3.7 mm long. *Ovules c.* 12 per locule, maturing 1–5 seeds per locule, 3–7 seeds per capsule. *Seeds* ±globular, 0.6–0.8 mm long, 0.5–0.7 mm diam., black, coarsely rounded-tuberculate, sub-shiny. **Fig. 3 A-D, F [left inflorescence only], G, H.**

Distribution: Only known from about eight localities around the Prince Regent River in the NW Kimberley.

Habitat: *Hypoxis cavernicola* has only been found in damp soil under rock overhangs below sandstone slopes, usually just above the level of a seepage patch or sandstone pavement. It frequently grows near or intermixed with other rock overhang specialists: *Cheilanthes* spp., *Micraira* sp. aff. *spiciforma*, *Mitrasacme graminea*, *Lindernia* sp. A Kimberley Flora, *Murdannia* sp. cf. *cryptantha*, *Stylidium muscicola* and *S. notabile*. *Drosera* sp. aff. *paradoxa*, and *Arthrochilus byrnesii* grow nearby at several sites, but are probably intruders rather than cave specialists like the other species.

Flowering/fruiting: Only observed flowering January to February, but possibly also March; plants are dormant by late April/May. Plants grown from a corm at Kings Park, Perth flowered in late February to early April 2008, opening each flower for one day, only early in the morning and closing early-mid afternoon, never to re-open.

Additional specimens: WESTERN AUSTRALIA: [localities withheld for conservation reasons]: 25 Jan. 2000, *M.D. Barrett 857* (PERTH); 26 Jan. 2000, *M.D. Barrett 899* (PERTH); 2 Feb. 2000, *M.D. Barrett 1040* (PERTH, DNA); 5 Jan. 2000, *M.D. Barrett 1084* (PERTH); cultivated, 5 Jan. 2011, *M.D. Barrett MDB 3239* (PERTH, BRI); 25 Jan. 2007, *R.L. Barrett & M.D. Barrett RLB 3876* (PERTH).

Etymology: The epithet is from the Latin *caverna* (cave), and *–cola* (dweller) in reference to the habitat under rock overhangs.

The vernacular name of Cave Star Lily is suggested.

Conservation status: *Hypoxis cavernicola* is listed by Jones (2015) as Priority Two under Department of Parks and Wildlife Conservation Codes for Western Australian Flora, under the name *Hypoxis* sp. Prince Regent River (*M.D.Barrett 924B*). *Hypoxis cavernicola* is known from about 8 collections, all made by M. and/or R. Barrett with the aid of a helicopter during wet-season surveys. The lack of other collections is due to the very specific habitat, remote distribution and strictly wet season flowering time. Within the distribution it is quite common in very specific and restricted micro-habitat. All populations are small and are probably often widely separated, although small overhangs can be numerous in some areas, for example at Mount Bomford. There would appear to be no anthropogenic threats to any of the current populations, and some occur within the Prince Regent River Nature Reserve. *Hypoxis cavernicola* has clearly evolved to exploit a particular niche with inherently small population size, and has likely adapted to cope with any effects of inbreeding depression.

Notes: *Hypoxis cavernicola* is distinctive in being a diminutive herb of sandstone rock overhangs, 5–8 cm high, with small sepals (2.8–3.1 mm long) and anthers (0.4–0.6 mm long). All other Australian *Hypoxis* species have larger plants, sepals and anthers, and are only incidentally found near rock overhangs.

A plant grown alone from a corm at Kings Park, Perth produced at least one seed per locule on all capsules (each locule had at least 1 and up to 5 fully developed seeds). Since only a single plant was present, and only a single flower was open at any time, these flowers were at least capable of being self-fertilised, and were probably self-pollinated (no pollinators were observed inside the glasshouse). However, fertility of selfed seeds thus produced is unknown. Other plants similarly cultivated produce seeds in 100% of capsules (n=50), and numerous seeds subsequently germinated spontaneously the following year. Flowers of cultivated plants were bagged to exclude pollinators (n=10), and 163 of 190 ovules matured seed (85.8%), compared to 179 of 203 ovules maturing seed (86.7%) in 10 un-bagged flowers. These results demonstrate a high rate of self-compatibility. Perianth segments close fully as the flowers age, bringing the anthers and style into close contact, and this may provide a mechanism for self-pollination. Since flowers always completely open (i.e. are not cleistogamous), it is possible that this species is preferentially outcrossing, with a self-pollination mechanism should pollination fail.

Hypoxis cavernicola is a true *Hypoxis* species, by virtue of possessing hairs on the leaves, rather than being glabrous as in the genus *Pauridia* Harvey (previously treated as *Hypoxis* sect. *Ianthe* (Salisb.) Benth. by Henderson, 1987, see Snijman and Kocyan, 2013). *Pauridia* species are found in southern Australia and South Africa. *Hypoxis cavernicola* is distinguished from all other Australian species of *Hypoxis* by the very small flowers (in all dimensions), especially in the perianth segments 2.4–3.1 (vs. >6 mm long in other Australian species), anthers 0.4–0.6 mm long (vs. (1–)1.8–4.5 mm long in other Australian species), and in its habitat being restricted to rock overhangs (vs. seasonal damplands and sand flats), and from all except *H. pratensis* var. *tuberculata* R.J.F.Hend. in having prominently tuberculate seeds (Figure 3G, H). These characters, although distinctive, are probably all apomorphic for the species, and provide no indication of relationships with other Australian species of *Hypoxis*.

The key in Henderson (1987: 179) can be modified to include the new species by inserting the following couplet below step 1, couplet 1:

1A. Perianth segments 2.4–3.1 mm long; Anthers 0.4–0.6 mm long; Inflorescences bearing 1–3 flowers ..... ***H. cavernicola***

1A: Perianth segments > 6 mm long; Anthers ≥ 1 mm long; Inflorescences often with >3 flowers **2**

Henderson (1987) described *Hypoxis nervosa* R.J.F.Hend. from the Kimberley and the Top End of the Northern Territory, which until now was the only species of *Hypoxis* known to occur in north-west Australia. The first specimens of *H. cavernicola* were found in January 2000, growing in a cave on Mt Bomford, Drysdale River Station. The peculiar habitat and diminutive habit were immediately distinctive. Further searches between 2000 and 2010 tuned up numerous further populations, as well as many populations of *H. nervosa* in the vicinity, but never in the same microhabitat. *Hypoxis nervosa* is a common and widespread species on swampy mud and sand flats in the north-west Kimberley, although collections are still sparse. The two species are clearly demarcated by habitat and several morphological characteristics, and the smaller species (*H. cavernicola*) is here described as new. Several populations of *H. nervosa* showed variation in perianth shape or colour, and further investigation of this variation is warranted.

Hypoxis nervosa R.J.F.Hend., *Fl. Austral.* 45: 489, 181 (1987). *Type*: Mitchell Plateau, N. Kimberley, Western Australia, 9 December 1982, *K.F. Kenneally* 8692 (*holo*: PERTH 01178733).

Hypoxis nervosa is illustrated in Fig. 3: flower (Fig. 3F, right inflorescence) and seed ornamentation (Fig. 3I-J).

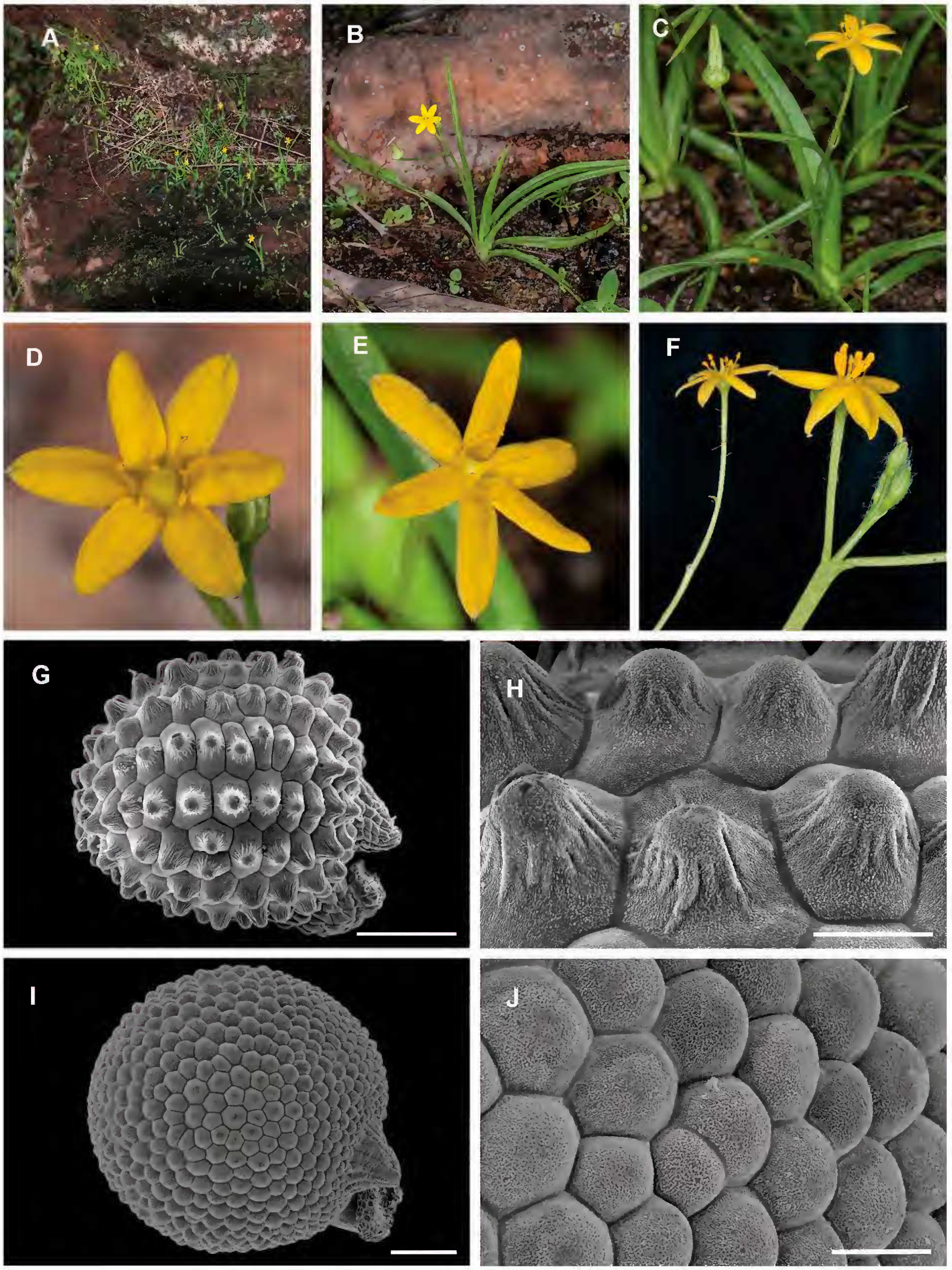

Fig. 3. *Hypoxis cavernicola*. **A**, habitat with other herbs under rock overhang; **B**, habit with once-branched inflorescence; **C**, habit with unbranched inflorescence, fruit and flower; **D**, **E**, flowers showing short anthers; **F**, comparison between flowers and inflorescence of *H. cavernicola* (left) and *H. nervosa* (right); **G**, SEM of seed; **H**, SEM of seed surface. *Hypoxis nervosa*. **I**, SEM of seed; **J**, SEM of seed surface. Scale bars = 200 μm (G, I); 50 μm (H, J). Images from Prince Regent River area, not vouchered (A–F); *M.D. Barrett MDB 1546* (G, H); *M.D. Barrett MDB 1084* (I, J). Photographs by R.L. Barrett (A–E); M.D. Barrett (F–J).

Notes: In Henderson (1987), flowers of *H. nervosa* were recorded as 'yellow (?pink)'. This comment presumably relates to the specimen I.M. Crawford 66 (PERTH 03914585), which the accompanying description records as having pink flowers. However, the specimen has yellow flowers when dry. In addition the brief description in Crawford (1982: 43, as *H. marginata*), for which this specimen was a voucher, also records the plant as having yellow flowers, and the label is presumably therefore an error.

According to the key in Henderson (1982), *H. marginata* and *H. nervosa* differ from other Australian species of *Hypoxis* in having the midrib and marginal veins conspicuously thickened and raised. On examination of fresh and dried collections I cannot discern this character in the new Kimberley material of *H. nervosa* (fairly uniformly sub-fleshy, with only inconspicuous veins present); however, all other characters are consistent with *H. nervosa*. Couplet 2 in Henderson's (1987) key may need to be amended accordingly (e.g. moving *H. nervosa* to somewhere near couplet 5–6, where it differs from *H. pratensis* in having perennial corm-units and usually 2–4 flowers per peduncle, and from *H. exilis* and *H. hygrometrica* by having a ±ovoid corm with a fibrous tunica).

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